Course guide
310610 - 310610 - Observation Adjustment in Geomatics

Last modified: 14/11/2023

Unit in charge: Barcelona School of Building Construction
Teaching unit: 749 - MAT - Department of Mathematics.

Degree: BACHELOR'S DEGREE IN GEOINFORMATION AND GEOMATICS ENGINEERING (Syllabus 2016). (Compulsory subject).

Academic year: 2023 **ECTS Credits:** 6.0 **Languages:** Catalan, English

LECTURER

Coordinating lecturer: Joan J. Rodríguez Jordana

Others: Pantazi, Chara

PRIOR SKILLS

It is essential to have basic knowledge of lineal algebra, infinitesimal calculus in one and various variables, descriptive statistics, probabibility and random variables.

REQUIREMENTS

It is recommended to have successfully taken the subjects Algebra and Calculus of the semester 1A and the subject Mathematical Methods of the semester 1B

DEGREE COMPETENCES TO WHICH THE SUBJECT CONTRIBUTES

Specific:
1. Knowledge, use and application of instruments and fotogrametric methods and topographic adequated to the realization of non-cartographic raisings.
2. Knowledge and application of methods of minimun adjust quadratic in the scope of topo-geodesic observations, photogrametric and cartographic.

Transversal:
5. THIRD LANGUAGE. Learning a third language, preferably English, to a degree of oral and written fluency that fits in with the future needs of the graduates of each course.

TEACHING METHODOLOGY

The following methodologies will be used:
Expository method for strictly theoretical content topics.
Expository-participatory class for most topics.
Solving exercises and problems
Practices with calculation software
Directed work and autonomous work

LEARNING OBJECTIVES OF THE SUBJECT

At the end of the course, students must have expanded their knowledge of statistics to inductive statistics and must have acquired the fundamentals of adjusting observations. More specifically, you must have learned to calculate confidence intervals, test hypotheses, calculate how the variance-covariance matrix propagates through the calculations, and do parametric estimation in scenarios of direct, indirect, conditional and mixed observations, with models linear and nonlinear mathematics. All this using the least squares method and robust estimation methods.

STUDY LOAD

Type	Hours	Percentage
Self study	90,0	60.00
Hours large group	24,0	16.00
Hours medium group	36,0	24.00

Total learning time: 150 h

CONTENTS

C1. Continuous random variables and inductive statistics

Description:
In this content the following topics are developed:
Continuous random variables. Normal, Chi square and Student t laws.
Parameters, statistics and estimators
The sample mean and variance estimators
Estimation by intervals. Central limit theorem
Confidence interval for the population mean and standard deviation
Hypothesis contrast
Hypothesis testing of a distribution function

Specific objectives:
At the end of this content, the students must be able to:
Make probabilistic calculations with the Normal, Chi square and Student t laws.
Define parameters, statistics and estimators and their properties
Define and calculate the sample mean and variance estimators
Define estimation by intervals. State the central limit theorem
Define and calculate confidence intervals for the population mean and standard deviation
Test hypothesis on means and standard deviations
Test the hypothesis of a distribution function

Related activities:
Theory classes
Problem classes
Practical classes in the laboratory with Matlab. Activity L1
Practical exam of questions. Activity Q1
Multiple choice theoretical test. Activity T1

Full-or-part-time: 16h
Theory classes: 3h
Practical classes: 3h
Self study : 10h

C3. Variance-Covariance Matrix

Description:
In this content the following topics are developed:
Joint probability distributions
Independent random variables
Covariance
Variance covariance matrix
Propagation of the variance covariance matrix in linear and nonlinear expressions

Specific objectives:
At the end of this content, the student body must be able to:
Define joint probability distributions and marginal distributions
Define independent random variables and check if two variables are independent
Define and calculate the covariance of random variable residuals
Define variance covariance matrix of a set of observations
Calculate the spread of the variance covariance matrix in linear and nonlinear expressions

Related activities:
Theory classes
Problem classes
Practical classes in the laboratory with Matlab. Activity L1
Practical exam of questions. Activity Q1
Multiple choice theoretical test. Activity T1

Full-or-part-time: 16h
Theory classes: 3h
Practical classes: 3h
Self study : 10h

C3. Indirect Observations. Linear Model

Description:
In this content the following topics are developed:
Linear Systems of Observation Equations
Mathematical and stochastic models
Resolution according to the criterion of maximum likelihood and least squares
Calculation of residuals, a posteriori reference variance and propagation of the error

Specific objectives:
At the end of this content, the student body must be able to:
Given a system of indirect observations with a linear model, propose the mathematical and stochastic models, define the least squares criterion, propose and solve the normal system and calculate the residuals, the posterior reference variance and the propagation of the error.

Related activities:
Theory classes
Problem classes
Practical classes in the laboratory with Matlab. Activity L1
Practical exam of questions. Activity Q1
Multiple choice theoretical test. Activity T1

Full-or-part-time: 27h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study : 15h

C4. Indirect Observations. Non Linear Model

Description:
In this content the following topics are developed:
Nonlinear Systems of Observation Equations
Mathematical and stochastic models
Linearization
Resolution according to the least squares criterion
Successive iterations
Calculation of residuals, goodness of fit test, a posteriori reference variance and propagation of the error

Specific objectives:
At the end of this content, the student body must be able to:
Given a system of indirect observations, propose the mathematical model of non-linear observation equations and the stochastic model, linearize the mathematical model, define the least squares criterion, propose and solve the normal system, iterate the process, calculate the residues, the a posteriori reference variance and error propagation and do a goodness-of-fit test. In your case, calculate the error ellipse.

Given a system of indirect observations with a non-linear model, propose the mathematical and stochastic models, linearize the mathematical model, define the criteria of maximum likelihood and least squares, propose and solve the normal system, iterate the process, calculate the residuals, do a goodness-of-fit test and calculate the posterior reference variance and the spread of the error.

Related activities:
Theory classes
Problem classes
Practical exercises in the Maple calculation laboratory. activity L2
Practical exam of questions. activity Q1
Theoretical test exam. activity T1
Work. activity T

Full-or-part-time: 37h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study : 25h

C5. Robust Methods in Geomatics

Description:
This content introduces robust estimation methods useful when there are observational data affected by gross errors.
Robust estimators
Least median method
RANSAC method

Specific objectives:
At the end of this content, the student should be able to
Define robust estimators of central tendency and dispersion
Make parametric estimation using the least median method and the RANSAC method

Related activities:
Theory classes
Problem classes
Practical exercises in the Maple calculation laboratory. Activity L3
Practical exam of questions. Activity Q2
Theoretical test exam. Activity T2

Full-or-part-time: 27h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study : 15h

C6. Condition Equation Model and General Least Squares Model

Description:
In this content the following topics are developed:
Fitting Observations Using a Linear Model of Condition Equations
Criteria of maximum likelihood and least squares
Precision in least squares estimation
Nonlinear equations of condition
General method of least squares

Specific objectives:
At the end of this content, the student body must be able to:
Formulate a system of condition equations corresponding to a set of observations
Define the least squares criterion
Make a least squares fit of observations in a linear and nonlinear model of condition equations and calculate the error of the fitted observations
Create a system of equations with observable variables and unknowns, solve it by least squares and calculate the error of the unknowns and of the adjusted observations

Related activities:
Theory classes
Kinds of problems
Practice in the calculation laboratory with Maple. Activity L4
Practical examination of questions. Activity Q2
Theoretical multiple choice test. Activity T2

Full-or-part-time: 27h
Theory classes: 4h 30m
Practical classes: 7h 30m
Self study : 15h

ACTIVITIES

Coursework

Description:
Work consisting of the design of a system of indirect observations, the corresponding compensation and the public presentation of the results

Specific objectives:
To design the observation system, the student body must have understood the concept of indirect observation, observation equation, error and weight.
To perform the calculations, the student body must have understood the compensation by least squares and acquired the necessary skills to carry it out with a symbolic calculation program.
To make the presentation, the student body must have developed transversal skills such as teamwork, oral and written expression and the solvent use of ICT resources.

To develop generic competence in a third language, the work must be written and defended in a third language.

Material:
Matlab and ppt programs

Delivery:
Matlab file with calculations and ppt file with presentation

Full-or-part-time: 8h
Theory classes: 4h
Self study: 4h

GENERIC COMPETENCE IN ENGLISH LANGUAGE

Description:
Practices in the calculation laboratory

Specific objectives:
When doing the practice, the student must be able to understand the sentences, move through the "help" of the program and express the results in English.

Material:
Maple program

Delivery:
Practice result file

Full-or-part-time: 1h
Theory classes: 1h

Activity L1

Description:
Practice with the Matlab program on random variables and samples

Specific objectives:
Learn to work with random variables and sample statistics with the Matlab program

Material:
Matlabprogram

Delivery:
Matlab file with results

Full-or-part-time: 2h
Theory classes: 2h

Activity L2

Description:
Practice in the calculation laboratory on indirect observations, with the Matlab program

Specific objectives:
Learn to work with indirect observations with the Matlab program

Material:
Maple program

Delivery:
Matlab file

Full-or-part-time: 2h
Theory classes: 2h

Activity L4

Description:
Practice in the calculation laboratory on conditional observations and general method, with the Matlab program

Specific objectives:
Learn to work with conditional observations and general method with the Matlab program

Material:
Matlab program

Delivery:
Matlab file with the result

Full-or-part-time: 2h
Theory classes: 2h

Activity L3

Description:
Practice in the calculation laboratory with the Matlab program on robust estimation

Specific objectives:
Learn to work with the Matlab program, to solve estimation problems using robust methods

Material:
Matlab program

Delivery:
File on Matlab support

Full-or-part-time: 2h
Theory classes: 2h

Activities T1 and T2

Description:
Theoretical content test

Specific objectives:
At the end of these activities, the student body must have verified the degree of achievement of the theoretical concepts corresponding to contents 1, 2, 3 and 4 for activity T1 and 5 and 6 for activity T2 respectively

Material:
Test

Delivery:
Answered test

Full-or-part-time: 1h
Theory classes: 1h

Activities Q1 and Q2

Description:
Practical question tests

Specific objectives:
At the end of these activities, the students must have verified the degree of achievement of the practical concepts and mechanisms for solving exercises, corresponding to contents 1, 2, 3 and 4 for activity Q1 and 5 and 6 for activity Q2 respectively.

Material:
Statements

Delivery:
Solved exercises

Full-or-part-time: 5h
Theory classes: 5h

GRADING SYSTEM

Contents 1 to 3
A test with questions and theory test: 30% of the final grade
Two practices in the calculation laboratory: 2.5% of the final mark each
Contents 4 to 6
A test with questions and theory test: 30% of the final grade
Two practices in the calculation laboratory: 2.5% of the final mark each
Work: 10% of the final grade
Attendance and class work: 20% of the final grade
Students who obtain a grade between 3.5 and 4.9 will have the right to a make-up test for the questions and test tests that add up to 60% of the final grade

EXAMINATION RULES.

The tests will be carried out in the mid-term and final exam weeks of the semester.

The practices will be done with the MATLAB program during school weeks number 3, 7, 12 and 15. The work will be the subject of an oral presentation and will be defended at school week number 10

BIBLIOGRAPHY

Basic:
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- Rodríguez Jordana, Joan. Ajuste de observaciones : el método de los mínimos cuadrados con aplicaciones a la topografía [on line]. Barcelona: Edicions UPC, 2002 [Consultation: 15/05/2020]. Available on: http://hdl.handle.net/2099.3/36636. ISBN 8483016176.

Complementary:
- Fischler, Martn A. & Bolles, Robert C.. "Random Sample Consensus: A Paradigm for Model Fitting with Applications to Image Analisys and Automated Cartography". Graphics and Image Processing [on line]. p. 381-395 [Consultation: 12/05/2017]. Available on: http://bit.ly/2pdjn9f.- Rousseeuw, Peter J. ; Leroy, Annick M.. Robust regression and outlaier detection. New York: John Wiley & Sons, 1987. ISBN 0-471-85233-3.
- Chueca, M.; Herráez, J.; Berné, J. L. Tratado de Topografía, vol. 2, Métodos topográficos. 1996. Madrid: Paraninfo, 1996. ISBN 8428323097.
- Lauf, G. B. The Method of least square with applications in surveying. 1983. Collingwood: Tafe Publications Unit, 1983. ISBN 0-7241-3531-6.
- Leick, Alfred. GPS satellite surveying. 4th ed. New York: John Wiley & Sons, 2015. ISBN 9781118675571.
- Mikhail, Edward M.; Gracie, Gordon. Analysis and adjustment of survey measurements. New York: Van Nostrand Reinhold, 1981. ISBN 0442253699.
- Slama, C. [ed]. Manual of photogrammetry. 5th ed. Virginia: American Society of Photogrammetry, 2004. ISBN 1570830711.
- Walpole, Ronald E.; Mayers, Raymond H. Probabilidad y estadística para ingenieros. 6ª ed. México: Prentice Hall, 1999. ISBN 9701702646.

RESOURCES

Audiovisual material:
- Nom recurs. Resource

Other resources:
The course has a space in thge virtual campus ATENEA where you can find
A link to the teaching guide
A PDF document where you can follow the activities while being developed
A repository of practices to resolve